National Semiconductor's Power Management Solutions for Xilinx® Field Programmable Gate Arrays (FPGAs)

Design Guide

Summer 2005

Your fast, accurate guide to choosing the best National Semiconductor Power Supply Solution, including: Voltage Regulators, Voltage Supervisors, and Voltage References.

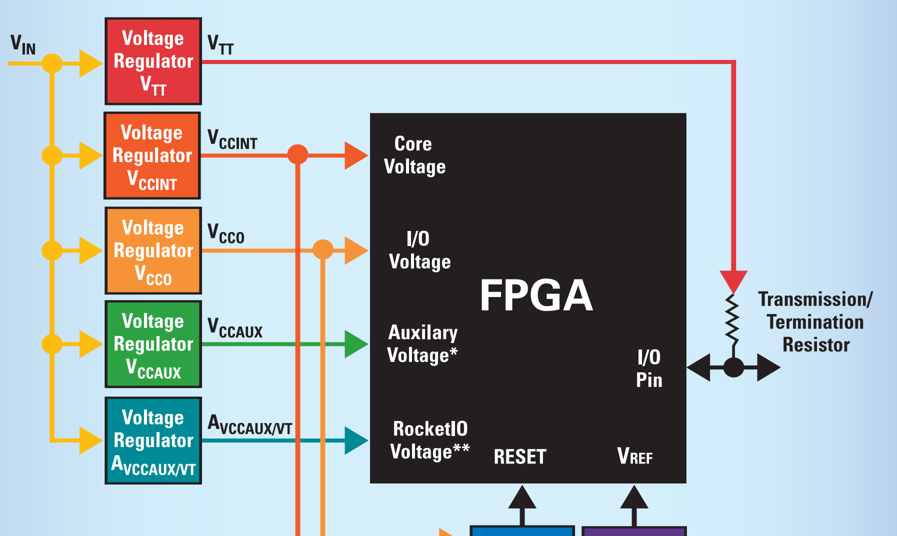
Xilinx Devices supported:
- Virtex™
- Virtex-E
- Virtex-II
- Virtex-II Pro
- Virtex-4FX, 4LX, 4SX
- Spartan™-II
- Spartan-IIE
- Spartan-3, 3E, 3L

National Devices supported:

Voltage Regulators
- Integrated Switchers
- Switching Controllers
- LDOs

Voltage Supervisors

Voltage References



Abbreviations	
V_{IN}	Input Voltage
V_{CCINT}	Core Voltage
V_{CCO}	I/O Voltage
V_{REF}	Reference Voltage
V_{CCAUX}	Auxiliary Voltage*
V_{TT}	Termination Voltage
$A_{VCCAUX/VT}$	RocketIO Voltage**

*Virtex-II, Virtex-II Pro, Virtex-4, and Spartan-3 only
** Virtex-II Pro, Virtex-4FX (except FX12), and Virtex-II ProX only

For the most up-to-date information, see National's Power Web site:

www.national.com/see/xilinxfpga

See the design details for power and other synergistic product areas:
- High speed amplifiers
- Data converters/temp sensors
- Interface/LVDS
- Broadcast Video

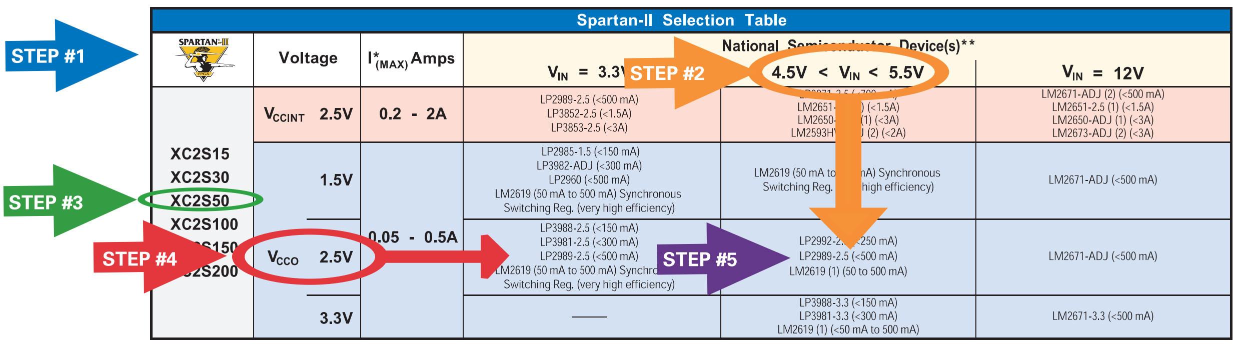
AVNET electronics marketing

National Semiconductor
The Sight & Sound of Information

Power management solutions for FPGAs

National Semiconductor, a leader in analog solutions, offers a broad portfolio of power solutions for Xilinx Field Programmable Gate Arrays (FPGAs). This design guide features individual National Semiconductor device solutions, listed by part number, for different Xilinx families. The parametric tables and sample reference designs will help guide the engineer towards a typical solution for their Xilinx design. Solutions include devices from the National Semiconductor Portfolio - Voltage Regulators, Voltage Supervisors, and Voltage References.

The Xilinx FPGA part numbers are used as a reference point to begin the process of determining the best National Semiconductor power solution. Refer to the step-by-step process shown below as a reference to using this design guide.



*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
**Suggested solutions are integrated regulators unless otherwise noted.

STEP #1 Locate the page number in the Table of Contents for the applicable Xilinx family.

STEP #2 Determine the input voltage range of the regulators. There are 3 options available: 3.3, 4.5-5.5, and 12V.

STEP #3 Choose the Xilinx part number.

STEP #4 Select the voltage (options include: V_{CCINT}, V_{CCO}, or V_{CCAUX}). For example, let's choose V_{CCO} @ 2.5V.

STEP #5 Using steps #2, #3 and #4 find the exact row and column intersection. A selection of multiple National Semiconductor devices will be offered.

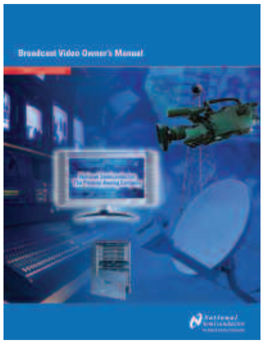
In addition to the selection tables, you will find a reference design for each Xilinx family, as well as more detailed descriptions on National Semiconductor's devices and design tools.

For more design information, please refer to these guides at www.national.com/guides

LVDS Owner's Manual

For more LVDS information:
www.LVDS.national.com

Broadcast Video Owner's Manual



For more interface information:
www.national.com/appinfo/interface

Ultra-fast ADC's and Amplifiers Guide

For more ADC or amplifiers information:
www.national.com/adc
www.amplifiers.national.com

Voltage definitions

V_{CCINT} **Voltage supply for the internal core logic**

The main power supply for the FPGA's internal logic. The internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from V_{CCINT}. All V_{CCINT} pins must connected together and have sufficient power supply decoupling to ensure proper operation. Typical V_{CCINT} voltages include: 1.2, 1.5, 1.8, or 2.5V, depending upon the individual FPGA family.

V_{CCO} **Output voltage supply for the I/O bank**

Each of the I/O banks have their own set of V_{CCO} power supply pins that power the output drivers, except when using the GTL and GTLP signal standards. The voltage on the V_{CCO} pin determines the voltage swing of the output signal. Typical V_{CCO} voltages include: 1.5, 1.8, 2.5, 3.0, or 3.3V, depending upon the individual FPGA family.

V_{CCAUX} **Voltage supply for the auxiliary logic**

The V_{CCAUX} pins supply power to various auxiliary circuits, for example, to the Digital Clock Managers (DCMs), the JTAG pins, and to the dedicated configuration pins. All V_{CCAUX} inputs must be connected together and have sufficient power supply decoupling to ensure proper operation. Typical V_{CCAUX} voltages include: 2.5 or 3.3V, depending upon the individual FPGA family. Caution must be exercised on the V_{CCAUX} pins because the DCMs are sensitive to voltage changes.

V_{TT} **Supply voltage for the I/O termination resistors**

The V_{TT} supply is used for the transmission and/or termination resistors.

V_{REF} **Input buffer reference voltage for the special interface standards**

Any low voltage I/O standards with a differential amplifier input buffer require an input reference voltage (V_{REF}). The V_{REF} pins collectively supply an input reference voltage, for any low voltage standard implemented in the associated I/O bank. Typical V_{REF} voltages include: 0.75, 0.8, 0.9, 1.0, 1.25, 1.32, or 1.5V, depending upon the individual FPGA family.

Power-on and voltage sequencing requirements

All Xilinx FPGAs are 100% guaranteed to the power-on ramp specifications listed (if any) in their respective datasheets.

http://www.xilinx.com/xlnx/xweb/xil_publications_index.jsp

Power-on, and quiescent currents specific to each family are also specified. The Design Guide's reference designs and components shown here, take all of the requirements into account, and have been designed to comply with the appropriate part's specifications. Operations outside of these specifications are not recommended. Note, power consumption varies by FPGA density and design; be sure to choose voltage regulators with sufficient current capability. There are no restrictions on the type of power regulator required for these devices.

There are no power supply sequence requirements for Xilinx FPGAs, unless there is a sequence that is needed for an application. For example, in a Hotswap application, the V_{CCO} voltage must be present before the I/O pins connect.

The Xilinx Virtex, Virtex-E, Spartan-II, Spartan-IIE, Spartan-3, and Virtex-4 FPGAs require a certain amount of supply or in-rush current during power-on to insure proper device initialization and operation. Consult with Xilinx's datasheets and application notes XAPP158 & XAPP450. In addition, there may be sequencing requirements for these devices.

All Xilinx FPGAs are tested between the ranges of 250 µs to 50 ms for the power-on ramp time (0 VDC to V_{CCINT} nominal). Current for the Virtex, Virtex-E, Spartan-II, Spartan-IIE, Spartan-3, and Virtex-4 families is specified at the power ramp-on rates in their respective datasheets. Operation with faster or slower ramps is not recommended, as the devices have not been tested at those ramp rates.

Commonly used topologies

Power supply requirements are important because of the complex initial conditions, transient behavior, turn-on, and turn-off specifications, among many others. Bypassing or decoupling the power supplies at the device (in the context of the device's application) also requires careful attention. A minimum of two voltages are needed to power FPGAs: one for the "core" (1.0V to 2.5V typ.) and one for the "I/Os" (3.3V typ.). Many FPGAs also require a third low-noise, low-ripple voltage to provide power to the auxiliary circuits. Typical voltages are 2.5V or 3.3V depending on the individual FPGA family.

Operating current for each of these voltages is not fixed and depends upon many application-related factors, such as FPGA speed, capacity utilization, and the like. Operating current can vary from as low as 100 mA to as high as 20A. Usually in these systems the input voltage is higher than any of the voltages supplied to the FPGA and hence needs to be stepped down and regulated. Shown are the most commonly used step-down configurations for FPGAs. They are the synchronous buck, the non-synchronous buck, the linear regulator, and the single inductor. Consideration of the system specifications and the regulator operation will determine the type of regulators to use. The following aspects also need to be considered to achieve successful designs.

- Use a linear regulator if the power dissipated within it is less than 1W
- Use a non-synchronous buck regulator if the input-to-output voltage ratio is less than 2:1 and the output current is less than 3A
- Use a synchronous buck regulator if the input-to-output voltage ratio is greater than 2:1 with the output current exceeding 5A

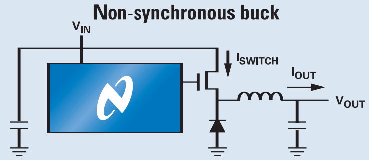
A regulator regulates the output voltage by comparing a reference voltage to a fraction of the output voltage appearing at the feedback pin. The reference voltage usually sets the minimum output voltage achievable.

Some controllers have a minimum on-time. This will limit the ability of the regulator to step down large amounts relative to the input. The minimum on-time (T_{ON} min.) of the controller limits also sets the minimum output voltage achievable at a given frequency. For example, the minimum on-time being exceeded will make the output voltage rise above the desired level.

V_{IN} = 12V
V_{OUT} = 1.2V
D = 1.2V/12V = 0.1
Fs = 300kHz
T_{ONmin} = 0.1 x 1/300kHz = 333ns

Decreasing the switching frequency will allow a greater step-down ratio.

Function: Step-down ($V_{OUT} < V_{IN}$)

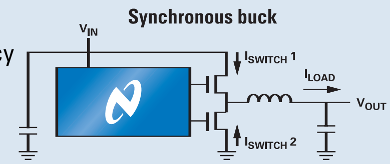


When to use: Typically when V_{IN} is 3x to 5x V_{OUT} and I_{OUT} is >0.5A and <5A

Characteristics: Easy to design and good efficiency for the above-mentioned typical $V_{IN}/V_{OUT}/I_{OUT}$ conditions

Devices to use: All buck integrated regulators and controllers

Function: Step-down ($V_{OUT} < V_{IN}$)

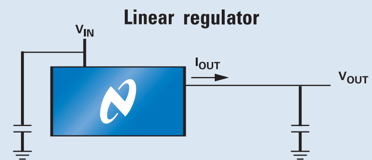


When to use: When high efficiency is required with high-output current (>5A) or low duty cycles (V_{IN} >5 x V_{OUT} and/or I_{OUT} <0.5A)

Characteristics: A second switch replaces the diode in the basic buck topology, reducing losses in the conditions mentioned above

Devices to use: Any "synchronous rectification" buck integrated regulator or controller

Function: Step-down ($V_{OUT} < V_{IN}$)



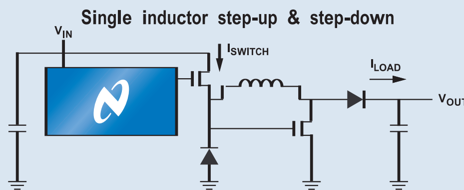
When to use: Typically when I_{OUT} < 1A, ultra low-dropout, and low-noise applications

Characteristics: Excellent option where fixed output, low current, and low voltage drops are required. Easy to implement

Devices to use: Any low-dropout, linear regulator

Comments: Great for micropower applications

Function: Buck-boost



When to use: When automatic step-up and step-down functionality is needed (For example, V_{IN} = 3.0V to 4.0V and V_{OUT} =3.3V) and no transformer or second inductor is desired (as with flyback or SEPIC topologies). This topology can be implemented on most existing buck regulator designs as offered in this Design Guide.

Characteristics: A second FET and output diode are added, effectively overlapping a boost topology on top of a basic buck topology. If desired, synchronous rectification can be implemented to increased efficiency (diodes may be replaced by FETs).

Devices to use: Any integrated buck regulator or controller, including SIMPLE SWITCHER buck regulators.

Comments: If V_{IN} is too high for the selected FET specifications, use voltage limiting circuitry.

Operating frequency of switching regulators
The switching frequency dictates several critical parameters including the size of inductors and capacitors, efficiency, ripple voltage, and ultimately the footprint of the solution. Higher switching frequency allows the designer to use smaller inductors as well as a smaller output capacitor to obtain a lower ripple voltage. Higher switching frequency also facilitates the design of high bandwidth systems. Additionally, the designer may need to operate outside a specific frequency band to prevent spurious interference. Using a buck regulator with adjustable frequency setting renders flexibility to the design.

Efficiency
The efficiency is the ratio of output power to input power and is an indication of the amount of wasted power. This is often a misunderstood parameter among system designers. If available input current is not limited or battery life is not critical, then the power dissipation—and not the efficiency alone— is what matters. The power dissipated in the system will directly affect the temperature rise of the system components, including the IC, MOSFETs, capacitors, and inductors. Also important is the power dissipated in a given area. As a general rule, with no airflow, 1W dissipated on one square inch of copper will have a temperature rise of 40°C.

For example, suppose:
V_{OUT} = 1.5V
I_{OUT} = 15A
Efficiency = 90%
Power Dissipation = 2.5W

If this power is dissipated on one square inch of copper it will give a 100°C temperature rise.

Also consider the following example:
V_{OUT} = 1.5V
I_{OUT} = 1.5A
Efficiency = 81%
Power Dissipation = 0.53W

This figure relative to the 90% efficiency in the previous example does not look so impressive. But power dissipation of only 0.53W on a one-inch square gives a temperature rise of only 20°C compared to 100°C in the previous example.

The power loss is more significant than the efficiency figure. Understanding this principle can help the designer optimize his or her efficiency demands and reduce the overall cost of the system.

Footprint
Reduction in area or height requirements will negatively impact both cost and efficiency for a particular design. For example, smaller inductors usually have a higher equivalent series resistance (ESR) than larger inductors. Low-profile inductors or low-profile electrolytic capacitors are generally more expensive. A multi-layer board minimizes the footprint, but generally increases overall cost.

Some designers may increase the switching frequency to reduce component sizes as discussed previously, but increasing the frequency will increase power losses. Making the board unnecessarily small usually costs more and may necessitate keeping the power losses lower than they need to be.

System costs
One aim of the designer is to optimize the cost of the FPGA power supply, but minimum supply costs does not necessarily equate to using the lowest cost regulator. For example, designers are sometimes quick to dismiss regulators with integrated FETs as being expensive, but in certain situations these can prove more economical than regulators with external MOSFETs. Moreover, regulators with external FETs are more sensitive to board layout. A simple integrated switching regulator with internal MOSFETs can eliminate most of the noise sensitivity issues.

Another example is dismissing the use of a dual buck converter in place of two single switching converters. Significant savings can be realized on the number of input capacitors required. Because the two phases can be made to operate out-of-phase, the RMS ripple current in the input capacitor is greatly reduced. Using a dual-phase controller can also eliminate beat frequencies that occur with non-synchronized switchers running at slightly different frequencies. Remember that true cost is the system Bill-of-Material (BOM) cost, not individual components alone. Beyond these requirements FPGA systems may have one or more of the specific requirements outlined on the following pages.

Power management considerations for FPGAs

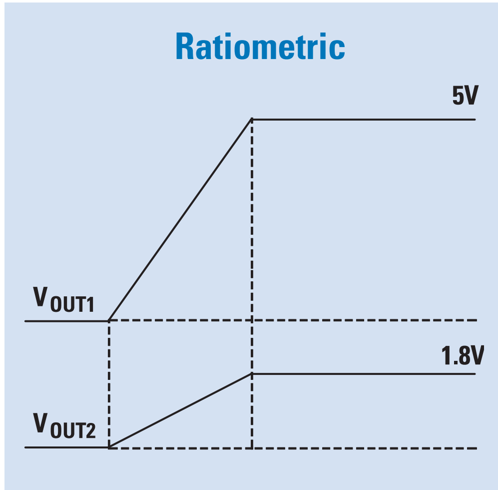
Transient response
The core voltage of the FPGA can produce extremely high slew rates on the operating current. This requires the controller to deliver large step-load current while minimizing perturbation on the output voltage. The ability of the controller to respond to these loads is also known as transient response. The transient response requirement dictates the operating bandwidth in conjunction with the output capacitance and its ESR.

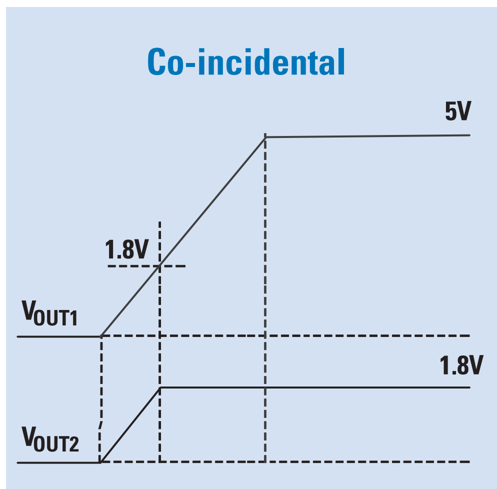
Sequencing and tracking
During start up, it may be necessary for one supply to ramp up before the other. If sequencing is ignored, the supply can “latch up” and the FPGA may be damaged or may malfunction. Some FPGAs have sequencing and/or tracking requirement between I/O and core voltages. (Refer to charts on the right for different types of sequencing and tracking options.) Sequencing and tracking can be simply or flexibly implemented if the regulators have integrated power good, enable, soft-start and tracking functions. If not, external circuitry will need to be included to ensure correct sequencing.

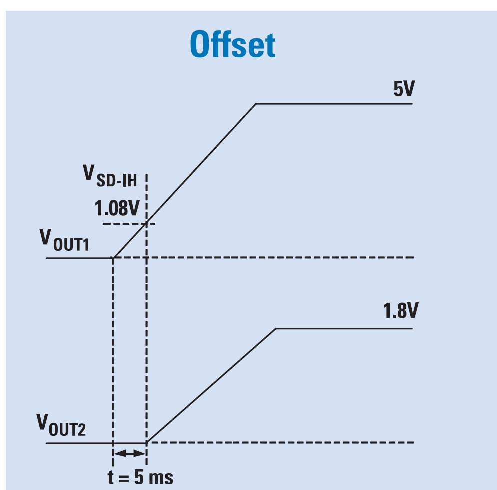
Start-up requirements
If the FPGA voltage requires a specific ramp rate, this can be implemented using a soft-start capacitor. Also, the rising voltage at start-up usually needs to be monotonic (not droop). If the supply output capacitances are small, this can cause the voltage at start-up to droop. Adequately sized capacitors store enough charge to supply the start-up load transient of the FPGA.

Synchronization
Synchronization enables two or more regulators to be locked together to one frequency. This eliminates the beat frequency that will otherwise be present if synchronization is not applied.

Summary of considerations
The best power supply configuration varies with the system requirements, as well as the complexity and capacity utilization of the FPGA or ASIC. Apart from the input voltage, output voltage, and output current, special requirements such as sequencing, tracking, and start-up conditions should be considered. Finally, power dissipation, footprint, and cost will influence the design.







LM2734
- +3.0 to 20V input
- +0.8V to 18V with a 1A output
- Current-Mode, PWM operation, internal soft-start
- Switching frequencies: 550 kHz (LM2734Y) 1.6 MHz (LM2734X)

LM2736
- +3.0 to 18V input
- +1.25V to 16V with a 750 mA output
- Current-Mode, PWM operation, internal soft-start
- Switching frequencies: 550 kHz (LM2736Y) 1.6 MHz (LM2736X)

LM2745
- Switching frequency: 50 kHz to 1 MHz (synchronize range 250 kHz to 1 MHz)
- Output voltage adjustable down to 0.6V
- Power Good flag and shutdown
- Adjustable softstart
- Startup with a pre-biased output load
- Power stage input voltage from 1V to 14V
- Control stage input voltage from 3V to 6V

LM2852
- +2.85 to 5.5V input with a 2A output current
- Voltage mode control
- Internal type three compensation
- Switching frequency: 500 kHz or 1.5 MHz

LM3475
- +0.8V to V_{IN} adjustable output
- High Efficiency (90% typical)
- 2 MHz switching frequency
- Hysteretic control scheme

LM3670
- +2.5 to 5.5V input with a 350 mA output
- V_{OUT} options: ADJ (.7V min), 1.2, 1.5, 1.6, 1.8, 1.875, 2.5, 3.3V
- Automatic PFM/PWM mode switching
- 1 MHz fixed frequency

LM2672/LM2673

- Wide input voltage range of +8V to +40V
- 260 kHz fixed frequency internal oscillator
- Soft-start and frequency synchronization
- Thermal shutdown and current limit protection
- Options
  LM2672: 1A output
  LM2673: 3A output

LP3981/LP3982

- Small LLP® space saving package
- 2.5V to 6V input with a 300 mA output current
- Over-temperature/over-current protection
- Standard voltage outputs
  LP3981: 2.5V, 2.7V, 2.8V, 2.83V, 3.03V, and 3.3V
  LP3982: 1.8V, 2.5V, 2.77V, 2.82V, 3.0V, 3.3V, and ADJ

LM2651/LM2655

- Ultra-high efficiencies up to 96%
- Adjustable soft-start
- Input undervoltage lockout
- Thermal shutdown
- 300 kHz fixed frequency internal oscillator
- Wide input range of +4.0V to +14V
- Internal MOSFET switch with low $R_{DS(on)}$
- Options
  LM2651: Synchronous, 1.5A output capacity
  LM2655: Synchronous or asynchronous, 2.5A output capacity

LMV431

- Low-voltage (1.24V) adjustable precision shunt
- Fast turn-on response

LM3671

- +2.8 to +5.5 input range
- 2 MHz PWM fixed switching frequency
- Multiple output voltage options from +1.2V to +1.875, including an adjustable version

I/O Standards

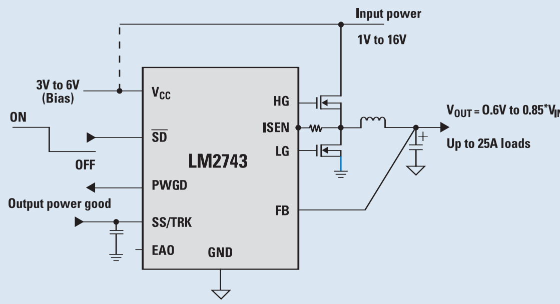
Standard Category	Description	V_{CCO} (V)	Class	Symbol
Single-Ended				
GTL	Gunning Transceiver Logic	N/A	Terminated	GTL
			Plus	GTLP
HSTL	High-Speed Transceiver Logic	1.5	I	HSTL_I
			III	HSTL_III
		1.8	I	HSTL_I_18
			II	HSTL_II_18
			III	HSTL_III_18
LVCMOS	Low Voltage CMOS	1.2	N/A	LVCMOS12
		1.5	N/A	LVCMOS15
		1.8	N/A	LVCMOS18
		2.5	N/A	LVCMOS25
		3.3	N/A	LVCMOS33
LVTTL	Low Voltage Transistor-Transistor Logic	3.3	N/A	LVTTL
PCI	Peripheral Component Interconnect	3.0	33 MHz	PCI33_3
SSTL	Stub Series Terminated Logic	1.8	N/A	SSTL18_I
		2.5	I	SSTL2_I
			II	SSTL2_II
Differential				
LDT	Lightning Data Transport (HyperTransport™)	2.5	N/A	LDT_25
LVDS	Low Voltage Differential Signaling		Standard	LVDS_25
			Bus	BLVDS_25
			Extended Mode	LVDSEXT_25
			Ultra	ULVDS_25
RSDS	Reduced-Swing Differential Signaling	2.5	N/A	RSDS_25

I/O Signal Standard definitions including V_{CCO} for Spartan-3 devices.

LM2743 Low-voltage synchronous buck controller

- Highly efficient 2A to 25A solution in SMD
- Input voltage from 1V to 16V
- Adjustable output voltage as low as 0.6V
- Power-good flag and output enable
- Output under-voltage and over-voltage flag
- 1.5% reference accuracy over temperature
- Current limit without sense resistor
- Programmable softstart
- Switching frequency from 50 kHz to 2 MHz
- Available in small TSSOP-14 packaging

LM2743 typical application diagram



Ideal for operation from 3.3V to 5V supplies in FPGA, DSP, and other high-current core regulator applications

Xilinx Virtex, Virtex-E reference designs and selection tables

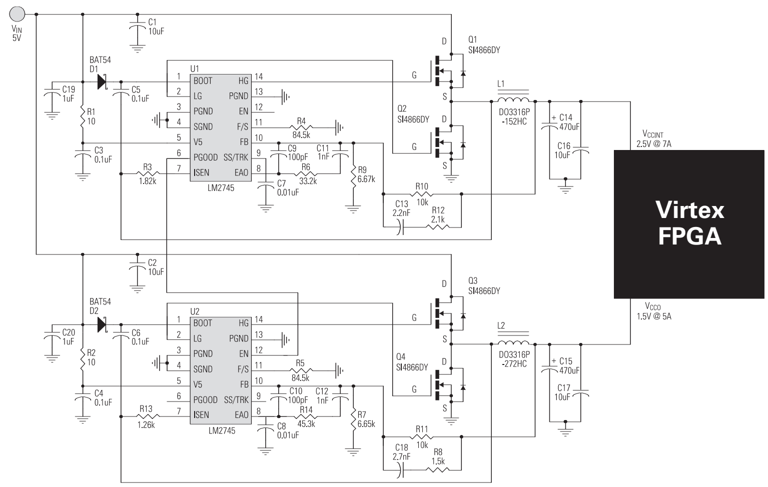
Virtex

The 2.5V Virtex family of FPGAs provide better performance designs with synchronous system clock rates up to 200 MHz including I/O. Both inputs and outputs comply fully with PCI specifications, and interfaces can be implemented that operate at 33 MHz or 66 MHz. Additionally, the Virtex family supports the hot-swapping requirements of Compact PCI.

Virtex devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +2.5V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Virtex design offers two independent LM2745 high-speed synchronous buck regulators. This design offers two outputs from a V_{IN} = 5V

- V_{CCINT} = 2.5V @ 7A
- V_{CCO} = 1.5V @ 5A



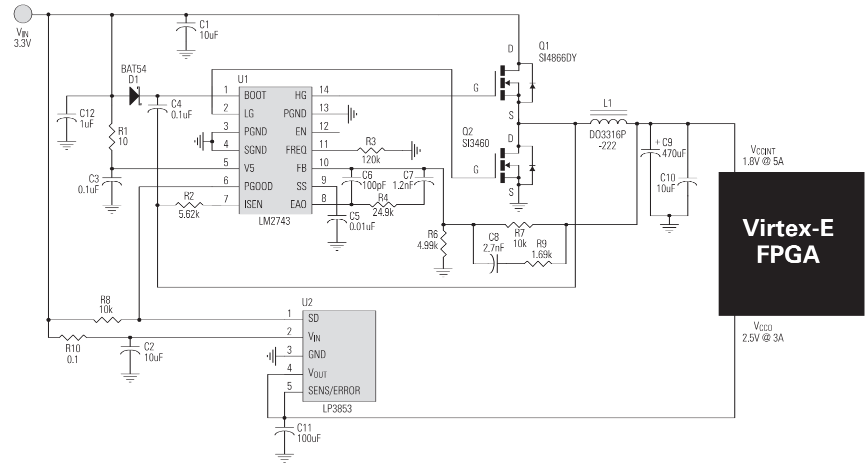
Virtex Selection Table					
VIRTEX	Voltage	I*(MAX) Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
XCV50 XCV100 XCV150 XCV200 XCV300	V_{CCINT} 2.5V	0.2 - 5A	LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 5A) Switching Controller	LP3871-2.5 (<700 mA) LM2745 (>2A) Sync Controller LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2852 (2A) Sync Regulator 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller (3)	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller (3)
	V_{CCO} 1.5V	0.05 - 3A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >3A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
	V_{CCO} 2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
	V_{CCO} 3.3V		——	LP3871-3.3 (<800 mA) LM28h52 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XCV400 XCV600 XCV800 XCV1000	V_{CCINT} 2.5V	0.2 - 7A	LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM2743 (2A to >7A) Switching Controller	LM2745 (>2A) Sync Controller LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2852 (2A) Sync Regulator 1/2 LM5642 (1) (2A to >7A) Sync Switching Controller (3)	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) 1/2 LM5642 (1) (2A to >7A) Switching Controller
	V_{CCO} 1.5V	0.05 - 5A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3874-ADJ (<500 mA) LM2745 (>2A) Sync Controller LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2852 (2A) Sync Regulator 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
	V_{CCO} 2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 5A) Switching Controller	LP3871-2.5 (<700 mA) LM2745 (>2A) Sync Controller LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2852 (2A) Sync Regulator 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
	V_{CCO} 3.3V		——	LP3871-3.3 (<800 mA) LM2745 (>2A) Sync Controller LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A) LM2852 (2A) Sync Regulator 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A) LM2679-3.3 (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
**Suggested solutions are integrated regulators unless otherwise noted.

Virtex-E

The 1.8V Virtex-E family of FPGAs provide better performance designs with synchronous system clock rates up to 240 MHz including I/O or 622 Mb/s using Source Synchronous data transmission architectures. Virtex-E I/Os comply fully with the 3.3V PCI specifications, and interfaces can be implemented that operate at 33 or 66 MHz. Additionally, the Virtex-E family supports the hot-swapping requirements of Compact PCI.

Virtex-E devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 1.8, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +1.8V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.



The Virtex-E design features a LM2743 and LP3853 ultra LDO regulator. This design offers two outputs from a V_{IN} = 3.3V

- V_{CCINT} = 1.8V @ 5A
- V_{CCO} = 2.5V @ 3A

Virtex-E Selection Table

VIRTEX-E	Voltage		I*(MAX) Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
XCV50E XCV100E XCV200E XCV300E	V_{CCINT}	1.8V	0.2 - 5A	LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller (3)
	V_{CCO}	1.5V	0.05 - 3A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >3A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500mA) LP3872-1.8 (<1.5 A) LM3477A (1A to >3A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XCV400E XCV600E XCV1000E XCV1600E XCV2000E XCV2600E XCV3200E	V_{CCINT}	1.8V	0.2 - 7A	LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >7A) Synch Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >7A) Sync Switching Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >7A) Switching Controller
	V_{CCO}	1.5V	0.05 - 5A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to 5A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 5A) Switching Controller	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A) LM2679-3.3 (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
**Suggested solutions are integrated regulators unless otherwise noted.

Xilinx Virtex-II reference design and selection table

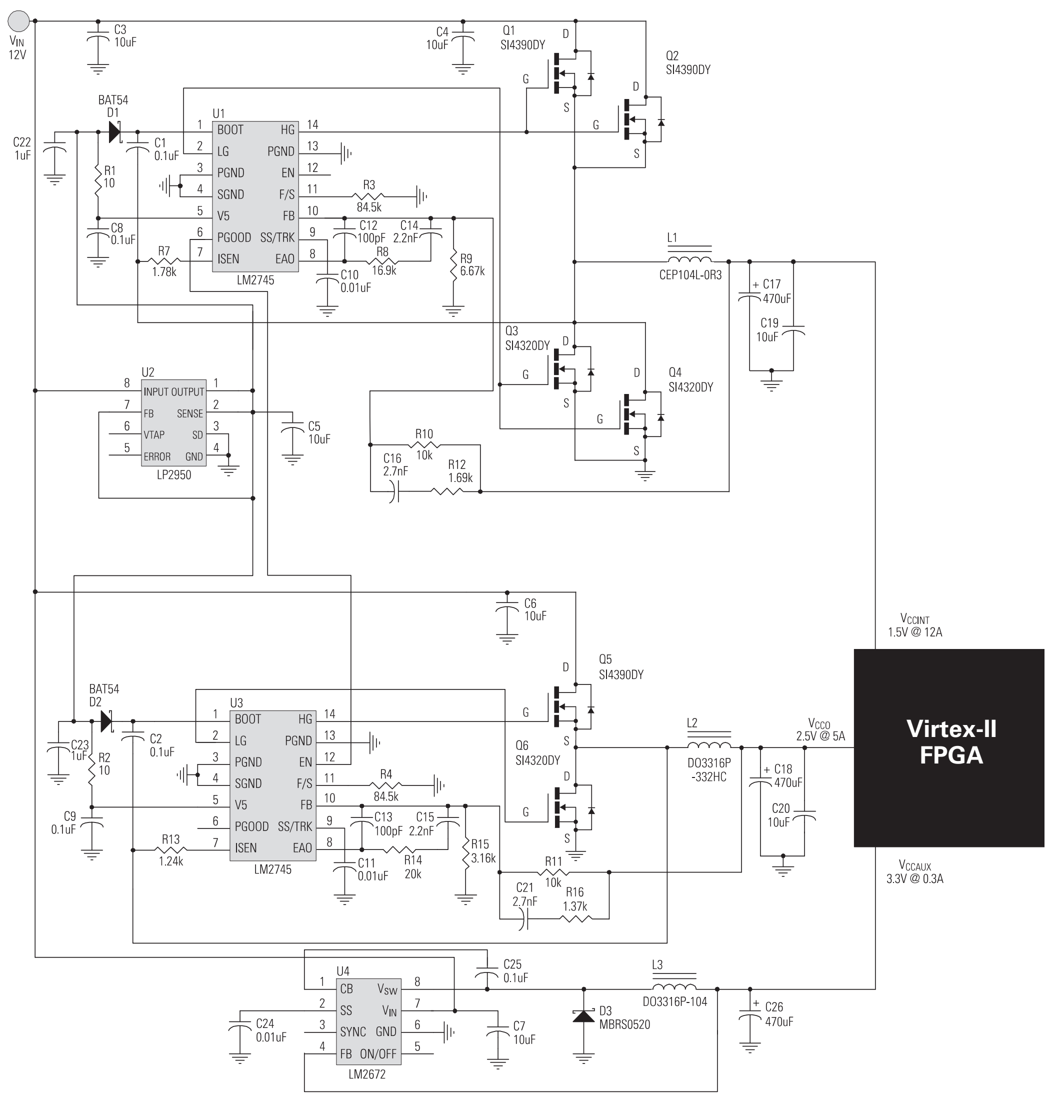
Virtex-II

The 1.5V Virtex-II family of FPGAs incorporates high logic capacity, up to 10 million system gates, a new Active Interconnect architecture optimized for predictable routing delays, an advanced memory array architecture with up to 4.5 Mbits of on-chip memory, and built-in support for high-speed I/O standards.

Virtex-II devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 1.8, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +1.5V. The V_{CCAUX} pins supply power to various auxiliary circuits, such as the Digital Clock Managers (DCMs), JTAG pins, and to the dedicated configuration pins. V_{CCAUX} must be +3.3V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Virtex-II design offers two independent LM2745 high-speed synchronous buck regulators, a LP2950 and a LM2672 SIMPLE SWITCHER® power converter regulator. The design offers 3 output voltages from a V_{IN} = 12V

- V_{CCINT} = 1.5V @ 12A
- V_{CCO} = 2.5V @ 5A
- V_{CCAUX} = 3.3V @ 0.3A



Virtex-II Selection Table

	Voltage		I*$_{(MAX)}$ Amps	National Semiconductor Device(s)**		
				V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
XC2V40 XC2V80 XC2V250 XC2V500	V_{CCINT}	1.5V	0.2 - 8A	LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >8A) Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >8A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >8A) Switching Controller (3)
	V_{CCAUX}	3.3V	0.3A	——	LP3981-3.3 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-3.3 (<500 mA)
	V_{CCO}	1.5V	0.05 - 2A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >2A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >2A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-3.3 (2) (<2A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC2V1000 XC2V1500 XC2V2000 XC2V3000	V_{CCINT}	1.5V	0.2 - 10A	LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >10A) Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >10A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >10A) Switching Controller (3)
	V_{CCAUX}	3.3V	0.3A	——	LP3981-3.3 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-3.3 (<500 mA)
	V_{CCO}	1.5V	0.05 - 3A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >3A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >3A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC2V4000 XC2V6000 XC2V8000	V_{CCINT}	1.5V	0.2 - 12A	LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >12A) Synch Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >12A) Sync Switching Controller	LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >12A) Switching Controller
	V_{CCAUX}	3.3V	0.3A	——	LP3981-3.3 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-3.3 (<500 mA)
	V_{CCO}	1.5V	0.05 - 5A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 5A) Switching Controller	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A) LM2679-3.3 (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
**Suggested solutions are integrated regulators unless otherwise noted.

Xilinx Virtex-II Pro reference design and selection table

Virtex-II Pro

The 1.5V Virtex-II Pro family of FPGAs incorporates embedded PPC405 cores and RocketIO Multi-Gigabit Transceivers. The embedded high-speed serial transceivers enable data bit rates up to 3.125 Gb/s per channel. And the IBM PowerPC 405 RISC processor blocks provide performance of 300+ MHz.

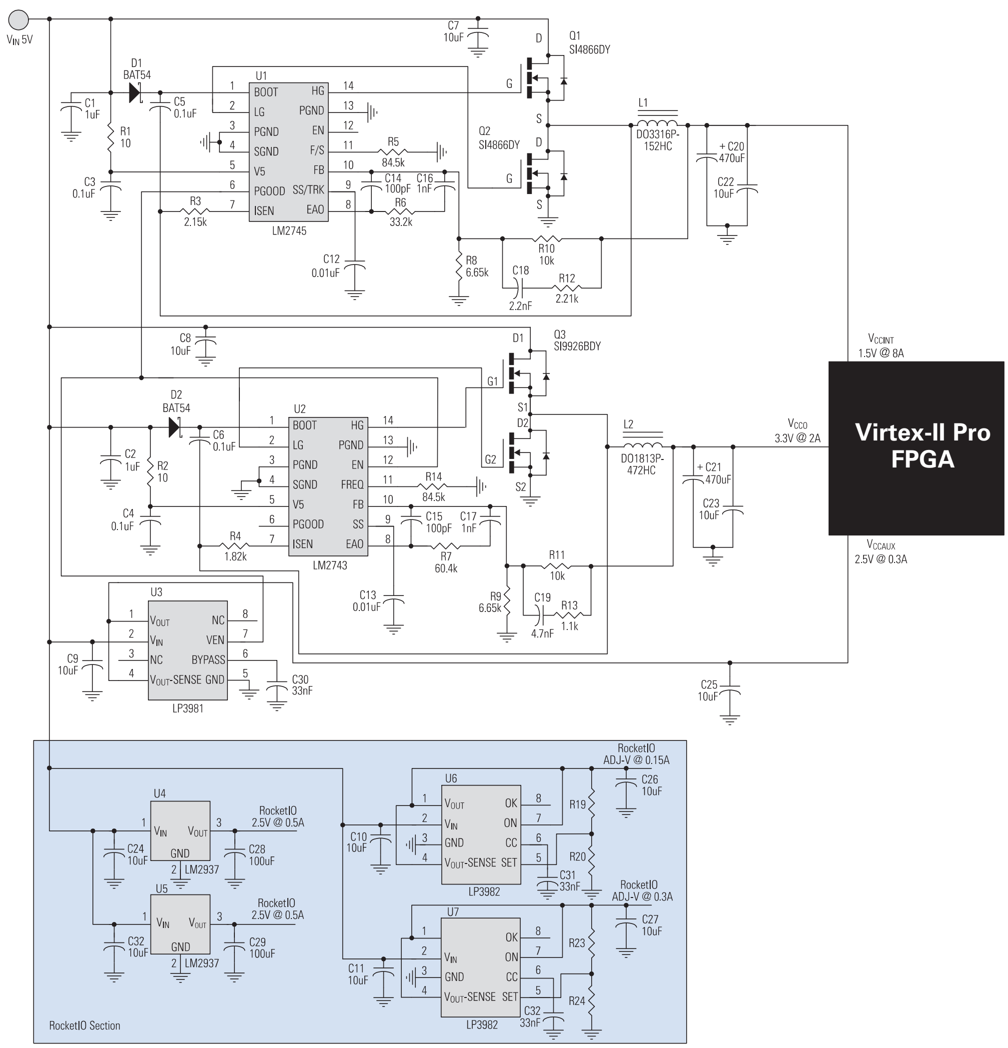
Virtex-II Pro devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 1.8, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +1.5V. The V_{CCAUX} pins supply power to various auxiliary circuits, such as the Digital Clock Managers (DCMs), JTAG pins, and to the dedicated configuration pins. V_{CCAUX} must be +2.5V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Virtex-II Pro design offers three devices, a LM2745 high-speed synchronous buck regulator, a LM2743 high-speed synchronous switching regulator controller, and a LP3981 LDO regulator. This design offers 3 outputs from a V_{IN} = 5V

- V_{CCINT} = 1.5V @ 8A
- V_{CCO} = 3.3V @ 2A
- V_{CCAUX} = 2.5V @ 0.3A

The RocketIO section includes two LP3982 and two LM2937 regulators. For additional power filtering requirements, refer to Xilinx's RocketIO Transceiver User Guide.

- $A_{VCCAUXTX}$ = 2.5V @ 0.5A
- $A_{VCCAUXRX}$ = 2.5V @ 0.5A
- A_{VTTX} = 1.8-2.625V @ 0.15A
- A_{VTRX} = 1.8-2.625V @ 0.3A



*Unused transceivers can be powered by any 2.5V source with no passive filtering required.

Virtex-II Pro Selection Table						
	Voltage		I*$_{(MAX)}$ Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	National Semiconductor Device(s)** 4.5V < V_{IN} < 5.5V	National Semiconductor Device(s)** V_{IN} = 12V
XC2VP2 XC2VP4 XC2VP7	V_{CCINT}	1.5V	0.2 - 8A	LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >8A) Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >8A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >8A) Switching Controller (3)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LP2989-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-ADJ (<500 mA)
	V_{CCO}	1.5V	0.05 - 2A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >2A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >2A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		———	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-3.3 (2) (<2A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC2VP20 XC2VP30 XC2VP40 XC2VP50	V_{CCINT}	1.5V	0.2 - 10A	LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >10A) Sync Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >10A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >10A) Switching Controller (3)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LP2989-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-ADJ (<500 mA)
	V_{CCO}	1.5V	0.05 - 3A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >3A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >3A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		———	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC2VP70 XC2VP100	V_{CCINT}	1.5V	0.2 - 12A	LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >12A) Sync Switching Controller	LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >12A) Sync Switching Controller	LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >12A) Switching Controller
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LP2989-2.5 LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-ADJ (<500 mA)
	V_{CCO}	1.5V	0.05 - 5A	LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >5A) Synch Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 5A) Switching Controller	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller
		3.3V		———	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A) LM2745 (>2A) Sync Controller 1/2 LM5642 (1) (2A to >5A) Sync Switching Controller	LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A) LM2679-3.3 (2) (<5A) 1/2 LM5642 (1) (2A to >5A) Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
**Suggested solutions are integrated regulators unless otherwise noted.

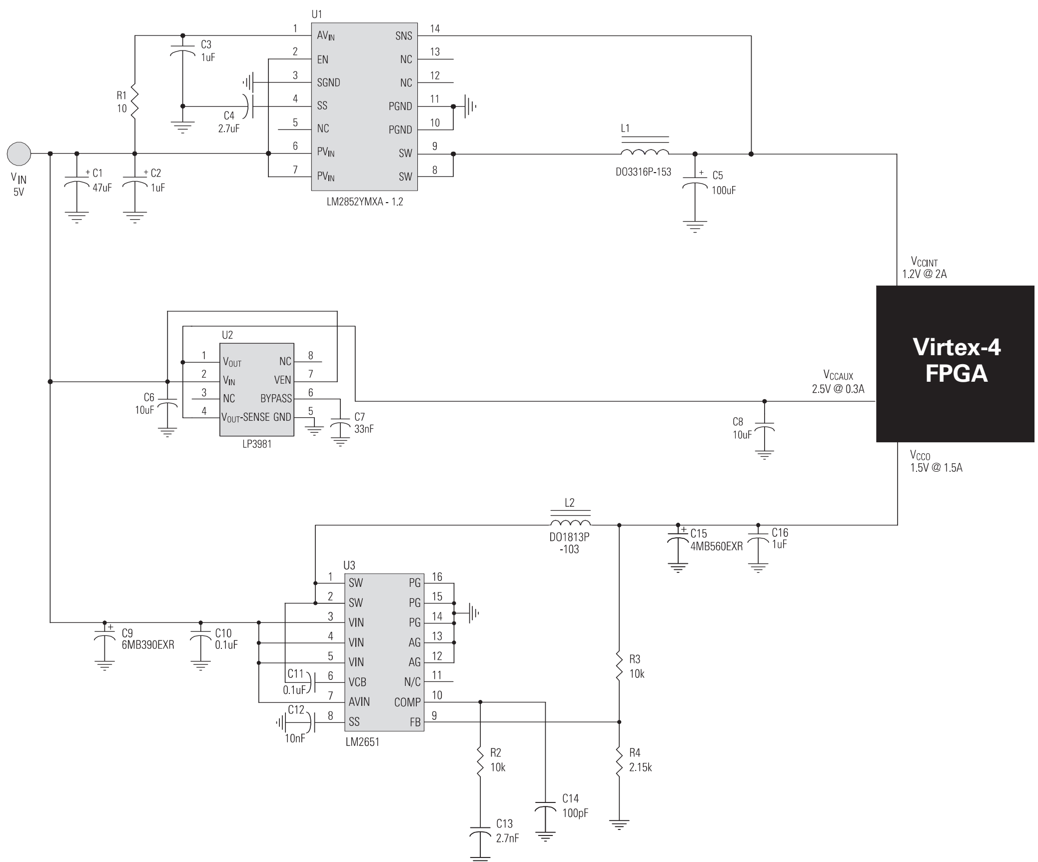
Xilinx Virtex-4FX, SX, and LX reference design and selection table

Virtex-4

The Virtex-4 Family is the newest generation FPGA from Xilinx. The innovative Advanced Silicon Modular Block or ASMBL™ column-based architecture is unique in the programmable logic industry. Virtex-4 FPGAs contain three families (platforms): FX, SX, and LX. Choice and feature combinations are offered for all complex applications. A wide array of hard-IP core blocks complete the system solution. These cores include the PowerPC™ processors (with a new APU interface), Tri-Mode Ethernet MACs, 622 Mb/s to 11.1 Gb/s serial transceivers, dedicated DSP slices, high-speed clock management circuitry, and source-synchronous interface blocks. The basic Virtex-4 building blocks are an enhancement of those found in the popular Virtex-based product families: Virtex, Virtex-E, Virtex-II, Virtex-II Pro, and Virtex-II Pro X, allowing upward compatibility of existing designs. Virtex-4 devices are produced on a state-of-the-art 90-nm copper process, using 300 mm (12 inch) wafer technology. Combining a wide variety of flexible features, the Virtex-4 family enhances programmable logic design capabilities and is a powerful alternative to ASIC technology.

The Virtex-4 design offers 3 independent regulators: The LM2852YMXA-1.2 Simple Synchronous™ Buck Regulator, the LP3981 Micropower LDO Regulator, and a LM2651 1.5A High Efficiency Synchronous Switching Regulator. The design offers three outputs from a V_{IN} = 5V:

- V_{CCINT} = 1.2V @ 2A
- V_{CCAUX} = 2.5V @ 0.3A
- V_{CCO} = 1.5V @ 1.5A



Virtex-4FX,SX,LX Selection Table

Device	Rail	Voltage	$I^*_{(MAX)}$ Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	National Semiconductor Device(s)** 4.5V < V_{IN} < 5.5V	National Semiconductor Device(s)** 8V < V_{IN} < 14V
XC4VLX15 XC4VLX25 XC4VSX25 XC4VSX35 XC4VFX12 XC4VFX20	V_{CCINT}	1.2V	0.2 - 3A	LP3875-ADJ (<1A) LM2734 (1) (<1A) Switching Controller LM3475 (1) (<3A) Switching Controller	LM2734 (1) (<1A) Switching Controller LM3475 (>3A) LM2743 (>3A)	LM2734 (1) (<1A) Switching Controller LM2673-ADJ (2) (<3A) 1/2 LM2647 (3) (>3A) or LM2743 (>3A)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670-2.5 (1)	LP3981-2.5 LM3670-2.5 (1)	LM2736 (1)
	V_{CCO}	1.2V	0.05 - 2A	LP3874-ADJ (<800 mA) LM2743 (1) (>2A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Switching Controller	LM2745 (>2A) Switching Controller 1/2 LM2647 (1) (>2A) Switching Controller
		1.5V		LM3671-1.5 (<500 mA) Switching Controller LP3874-ADJ (<800 mA) LP3875-ADJ (<1A) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM3671-1.5 (<500 mA) Switching Controller LP3874-ADJ (<800 mA) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2651 (>1A) Switching Controller
		1.8V		LM3671-1.8 (<500 mA) Switching Controller LP3874-1.8 (<800 mA) LP3875-1.8 (<1A) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM3671-1.8 (<500 mA) Switching Controller LP3874-1.8 (<800 mA) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller
		2.5V		LM3671-ADJ (<500 mA) Switching Controller LP3874-2.5 (<800 mA) LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LP3871-ADJ (<500 mA) Switching Controller LP3874-2.5 (<800 mA) LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller
		3.3V		——	LM3671-ADJ (<500 mA) Switching Controller LP3874-3.3 (<800 mA) LP3875-3.3 (<1A) LM2734 (<1A) Switching Controller LM2852 (<2A) Sync Regulator	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller
XC4VLX40 XC4VLX60 XC4VLX80 XC4VSX55 XC4VFX40 XC4VFX60	V_{CCINT}	1.2V	0.2 - 4A	LP3875-ADJ (<1A) LM2743 (1) (<1A) Switching Controller LM3475 (1) (<3A) Switching Controller	LM2734 (1) (<1A) Switching Controller LM3475 (<3A) LM2743 (>3A)	LM2734 (1) (<1A) Switching Controller LM2673-ADJ (2) (<3A) 1/2 LM2647 (3) (>3A) or LM2743 (>3A)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670-2.5 (1)	LP3981-2.5 LM3670-2.5 (1)	LM2736 (1)
	V_{CCO}	1.2V	0.05 - 3A	LP3874-ADJ (<800 mA) LM2743 (1) (>3A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Switching Controller	LM2745 (>2A) Switching Controller 1/2 LM2647 (1) (>3A) Switching Controller
		1.5V		LM3671-1.5 (<500 mA) Switching Controller LP3875-ADJ (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A)	LM3671-1.5 (<500 mA) Switching Controller LP3874-ADJ (<800 mA) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3)	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3)
		1.8V		LP3874-1.8 (<800 mA) LP3875-1.8 (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A)	LM3671-1.8 (<500 mA) Switching Controller LP3874-1.8 (<800 mA) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3)	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3)
		2.5V		LP3874-2.5 (<800 mA) LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A)	LP3874-2.5 (<800 mA) LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3)	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3)
		3.3V		——	LP3874-3.3 (<800 mA) LP3875-3.3 (<1A) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3)	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3)
XC4VLX100 XC4VLX160 XC4VLX200 XC4VFX100 XC4VFX140	V_{CCINT}	1.2V	0.2 - 5A	LP3875-ADJ (<1A) LM2734 (<1A) Switching Controller (1) LM3475 (<3A) Switching Controller (1)	LM2734 (<1A) Switching Controller (1) LM3475 (<3A) LM2743 (>3A)	LM2734 (<1A) Switching Controller (1) LM2673-ADJ (2) (<3A) 1/2 LM2647 (3) (>3A) or LM2743 (>3A)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM3670-2.5 (1)	LP3981-2.5 LM3670-2.5 (1)	LM2736 (1)
	V_{CCO}	1.2V	0.05 - 4A	LP3874-ADJ (<800 mA) LM2743 (1) (>4A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Switching Controller	LM2745 (>2A) Switching Controller 1/2 LM2647 (1) (>4A) Switching Controller
		1.5V		LP3875-ADJ (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A) LM2743 (>3A)	LP3874-ADJ (<800 mA) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3) LM2743 (>3A)	LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3) LM2679-ADJ (<5A) 1/2 LM2647 (4) (>6A) or LM2743
		1.8V		LP3875-1.8 (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A) LM2743 (>3A)	LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3) LM2743 (>3A)	LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3) LM2679-ADJ (<5A) 1/2 LM2647 (4) (>6A) or LM2743
		2.5V		LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM3475 (<3A) LM2743 (>3A)	LP3875-2.5 (<1A) LM2734 (<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3) LM2743 (>3A)	LM2736 (<500 mA) Switching Controller LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3) 1/2 LM2647 (4) (>6A) or LM2743
		3.3V		——	LP3875-3.3 (<1A) LM2734(<1A) Switching Controller LM2599-ADJ (2) or LM2650-ADJ (3) LM2743 (>3A)	LM2734 (<1A) Switching Controller LM2673-ADJ (2) or LM2650-ADJ (3) 1/2 LM2647 (4) (>6A) or LM2743

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) LDO option not applicable due to thermal constraints (heat dissipation) for the given operating conditions.
(2) Buck regulator. Good efficiency. Simple implementation. WEBENCH tools available.
(3) Synchronous buck converter. Maximum efficiency. No external diode required.
(4) One half of a dual converter, such as the LM2647, can be used to power V_{CCINT} while the other half can be used to power V_{CCIO}.
**Suggested solutions are integrated regulators unless otherwise noted.

Xilinx Spartan-II and IIE reference designs and selection tables

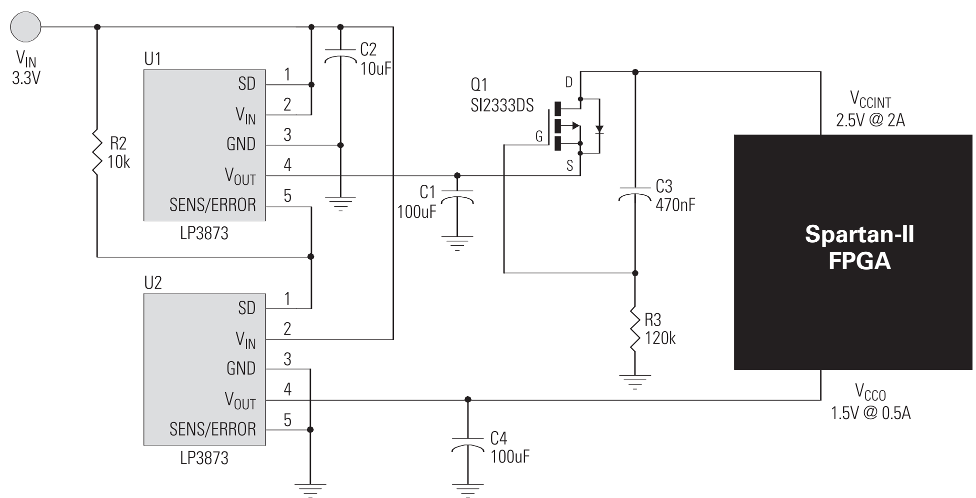
Spartan-II

The 2.5V Spartan-II family of FPGAs offers six family members with densities from 15,000 to 200,000 system gates. System performance is supported to 200 MHz.

Spartan-II devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +2.5V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Spartan-II design offers two independent LP3873 linear regulators. This design offers two output voltages from a V_{IN} voltage of 3.3V

- V_{CCINT} = 2.5V @ 2A
- V_{CCO} = 1.5V @ 0.5A



Spartan-II Selection Table						
SPARTAN-II	Voltage		$I^*_{(MAX)}$ Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	$4.5V < V_{IN} < 5.5V$	V_{IN} = 12V
XC2S15 XC2S30 XC2S50 XC2S100 XC2S150 XC2S200	V_{CCINT}	2.5V	0.2 - 2A	LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (<2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
	V_{CCO}	1.5V	0.05 - 0.5A	LP2985-1.5 (<150 mA) LP3982-ADJ (<300 mA) LP2960 (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (<2A) Sync Regulator	LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (<2A) Sync Regulator	LM2671-ADJ (<500 mA)
		2.5V		LP3988-2.5 (<150 mA) LP3981-2.5 (<300 mA) LP2989-2.5 (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (<2A) Sync Regulator	LP2992-2.5 (<250 mA) LP2989-2.5 (<500 mA) LM2619 (1) (50 to 500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (<2A) Sync Regulator	LM2671-ADJ (<500 mA)
		3.3V		—	LP3988-3.3 (<150 mA) LP3981-3.3 (<300 mA) LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (<2A) Sync Regulator	LM2671-3.3 (<500 mA)

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
**Suggested solutions are integrated regulators unless otherwise noted.

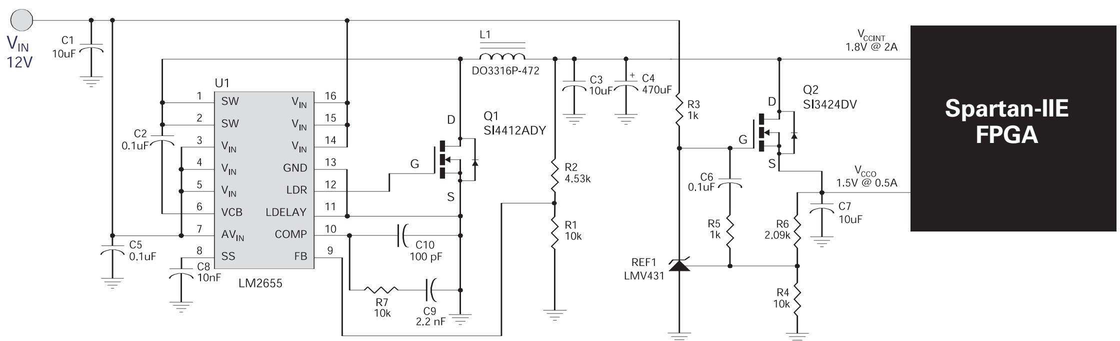
Spartan-IIE

The 1.8V Spartan-IIE family of FPGAs offers seven family members with densities from 50,000 to 600,000 system gates. System performance is supported beyond 200 MHz. Spartan-IIE devices also offer on-chip synchronous single-port and dual-port RAM.

Spartan-IIE devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.5, 1.8, 2.5, and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +1.8V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Spartan-IIE design features the LM2655 high efficiency synchronous switching regulator and the LMV431 shunt regulator. This design offers two output voltages from a V_{IN} voltage of 12V

- V_{CCINT} = 1.8V @ 2A
- V_{CCO} = 1.5V @ 0.5A



Spartan-IIE Selection Table

	Voltage		I*$_{(MAX)}$ Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
XC2S50E XC2S100E XC2S150E XC2S200E XC2S300E	V_{CCINT}	1.8V	0.2 - 2.0A	LP2989LV (4) (<500 mA) LP3872-1.8 (4) (<1.5A) LM3477A (1A to >2A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
	V_{CCO}	1.5V	0.05 - 0.5A	LP2985-1.5 (4) (<150 mA) LP2992-1.5 (4) (<250 mA) LP2960 (4) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA)	LM3670 (<350 mA) LM3671 (<600 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller	LM2671-ADJ (<500 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		1.8V		LP2985-1.8 (4) (<150 mA) LP2992-1.8 (4) (<250 mA) LP2989LV (4) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA)	LM3670 (<350 mA) LM3671 (<600 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller	LM2671-ADJ (<500 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		2.5V		LP3988-2.5 (1) (<150 mA) LP3981-2.5 (1) (<300 mA) LP2989-2.5 (1) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA)	LP2992-2.5 (<250 mA) LP2989-2.5 (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-ADJ (<500 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		3.3V		——	LP2992-3.3 (<250 mA) LM3670 (<350 mA) LM3671 (<600 mA)	LM2671-3.3 (<500 mA) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
XC2S400E XC2S600E	V_{CCINT}	1.8V	0.2 - 3.0A	LP2989LV (4) (<500 mA) LP3872-1.8 (4) (<1.5A) LM3477A (1A to >3A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
	V_{CCO}	1.5V	0.05 - 0.75A	LP2985-1.5 (4) (<150 mA) LP2992-1.5 (4) (<250 mA) LP2960 (4) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LP3874-ADJ (4) (<800 mA)	LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (2A) Sync Regulator LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller	LM2671-ADJ (<500 mA) LM2672-ADJ (<1A) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		1.8V		LP2985-1.8 (4) (<150 mA) LP2992-1.8 (4) (<250 mA) LP2989LV (4) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LP3871-1.8 (4) (<800 mA)	LM3670 (<350 mA) LM3671 (<600 mA) LM2852 (2A) Sync Regulator LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller	LM2671-ADJ (<500 mA) LM2672-ADJ (<1A) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		2.5V		LP3988-2.5 (4) (<150 mA) LP3981-2.5 (4) (<300 mA) LP2989-2.5 (4) (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LP3871-2.5 (4) (<800 mA)	LP2992-2.5 (<250 mA) LP2989-2.5 (<500 mA) LM3670 (<350 mA) LM3671 (<600 mA) LP3871-2.5 (<800 mA) LM2852 (2A) Sync Regulator	LM2671-ADJ (<500 mA) LM2672-ADJ (<1A) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller
		3.3V		——	LP2992-3.3 (<250 mA) LM3670 (<350 mA) LM3671 (<600 mA) LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator	LM2671-3.3 (<500 mA) LM2672-3.3 (<1A) LM2736 (<750 mA) Switching Controller LM2734 (<1A) Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
(4) LDO solution. Minimal external components required.
**Suggested solutions are integrated regulators unless otherwise noted.

Xilinx Spartan-3, 3E, and 3L reference design and selection table

Spartan-3

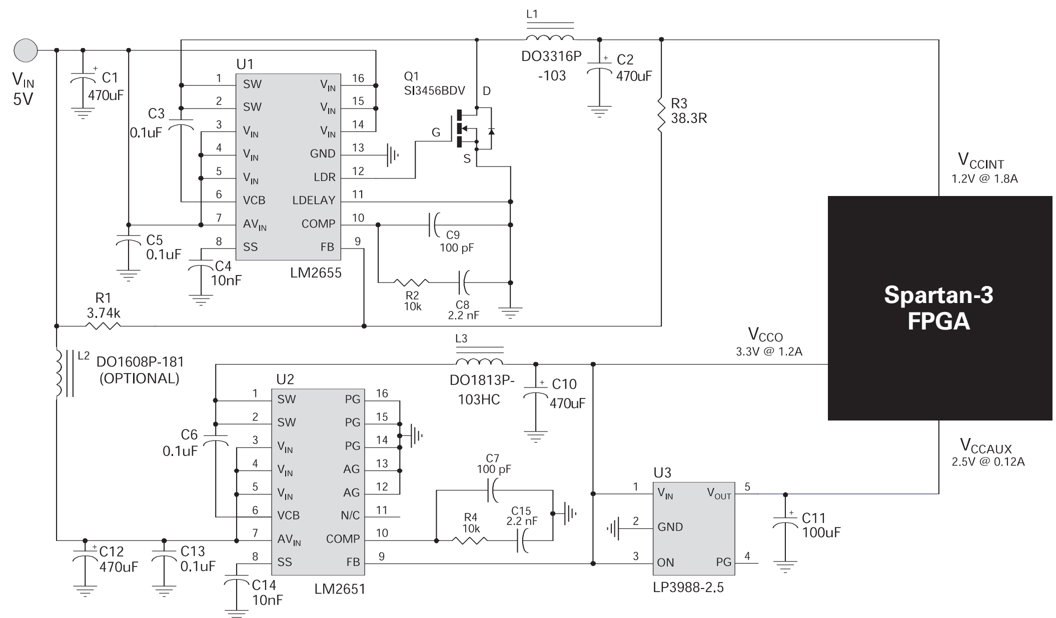
The 1.2V Spartan-3 family of Field Programmable Gate Arrays offers 8 members with densities ranging from 50K to 5M system gates. The Spartan-3L family offers 3 devices with reduced power (up to 98% lower power consumption) and an exclusive hibernate mode that fits seamlessly with systems using power management. The Spartan-3 EasyPath™ FPGAs further extend the benefits of the Spartan-3 FPGA family to volume production with a conversion-free, no-risk methodology that delivers up to 60% cost reduction.

Spartan-3 devices are designed and characterized to support various I/O standards for V_{CCO} values of 1.2, 1.5, 1.8, 2.5, 3.0 and 3.3V. Internal core logic circuits such as the Configurable Logic Blocks (CLBs) and programmable interconnect operate from the V_{CCINT} voltage supply pins. V_{CCINT} must be +1.2V. The V_{CCAUX} pins supply power to various auxiliary circuits, such as the Digital Clock Managers (DCMs), JTAG pins and the dedicated configuration pins. V_{CCAUX} must be +2.5V. Also, there must be sufficient supply decoupling on all supply lines to guarantee problem-free operation.

The Spartan-3 design offers the LM2651 (1.5A) and LM2655 (2.5A) high efficiency synchronous switching regulators, and a LP3988 ultra low-dropout CMOS voltage regulator capable of supplying 150 mA of load current. This design offers three output voltages from a V_{IN} voltage of 5V

- V_{CCINT} = 1.2V @ 1.8A
- V_{CCO} = 3.3V* @ 1.2A
- V_{CCAUX} = 2.5V @ 0.12A

* Note- For proper voltage regulation when V_{CCO} = 3.3V, refer to the Spartan-3 datasheet, module 2 for more details.



Spartan-3,-3E,-3L Selection Table						
	Voltage		$I^*_{(MAX)}$ Amps	National Semiconductor Device(s)** V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
XC3S50 XC3S200 XC3S400 XC3S100E XC3S250E XC3S500E XC3S1000L	V_{CCINT}	1.2V	0.2 - 3A	LP3874-ADJ (<800 mA) LM2743 (1) (>3A) Sync Switching Controller	LM2655 (1) (<2.5A) LM2745 (>2A) Sync Controller	LM2737 (1) (>3A) Switching Controller 1/2 LM2647 (1) (>3A) Switching Controller (3)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM2619 (1)	LP2989-2.5 LM2619 (1)	LM2671-ADJ
	V_{CCO}	1.2V	0.05 - 2A	LP3874-ADJ (<800 mA) LM2743 (1) (>2A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Sync Controller	LM2737 (1) (>2A) Switching Controller 1/2 LM2647 (1) (>2A) Switching Controller
		1.5V		LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >2A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >2A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.0V		LP3856-ADJ (<1A) LP2975 (1A to >2A)	LP3874-ADJ (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-ADJ (2) (<2A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2593HV-3.3 (2) (<2A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC3S1000 XC3S1500 XC3S2000 XC3S1200E XC3S1600E XC3S1500L XC3S4000L	V_{CCINT}	1.2V	0.2 - 4A	LP3874-ADJ (<800 mA) LM2743 (1) (>4A) Sync Switching Controller	LM2655 (1) (<2.5A) LM2745 (>2A) Sync Controller	LM2737 (1) (>4A) Switching Controller 1/2 LM2647 (1) (>4A) Switching Controller (3)
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM2619 (1)	LP2989-2.5 LM2619 (1)	LM2671-ADJ
	V_{CCO}	1.2V	0.05 - 3A	LP3874-ADJ (<800 mA) LM2743 (1) (>3A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Sync Controller	LM2737 (1) (>3A) Switching Controller 1/2 LM2647 (1) (>3A) Switching Controller
		1.5V		LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to >3A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (1A to >3A) Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A)	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2651-2.5 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.0V		LP3856-ADJ (<1A) LP2975 (1A to >3A)	LP3874-ADJ (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A)	LM2671-ADJ (2) (<500 mA) LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A)
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A)	LM2671-3.3 (2) (<500 mA) LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A)
XC3S4000 XC3S5000	V_{CCINT}	1.2V	0.2 - 5A	LP3874-ADJ (<800 mA) LM2743 (1) (>5A) Sync Switching Controller	LM2655 (1) (<2.5A) LM2745 (>2A) Sync Controller	LM2737 (1) (>5A) Switching Controller 1/2 LM2647 (1) (>5A) Switching Controller
	V_{CCAUX}	2.5V	0.3A	LP3981-2.5 LM2619 (1)	LP2989-2.5 LM2619 (1)	LM2671-ADJ
	V_{CCO}	1.2V	0.05 - 4A	LP3874-ADJ (<800 mA) LM2743 (1) (>4A) Sync Switching Controller	LP3881-1.2 (<500 mA) LM2745 (>2A) Sync Controller	LM2737 (1) (>4A) Switching Controller 1/2 LM2647 (1) (>4A) Switching Controller
		1.5V		LP3982-ADJ (<300 mA) LP3874-ADJ (<800 mA) LP3875-ADJ (<1.3A) LM3477A (1A to 4A) Switching Controller	LP3874-ADJ (<500 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM2647 (1) (2A to >4A) Sync Switching Controller
		1.8V		LP2989LV (<500 mA) LP3872-1.8 (<1.5A) LM3477A (2) (1A to >3A) Switching Controller LM2743 (1) (2A to >4A) Synch Switching Controller	LP3871-1.8 (<600 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller	LM2651-1.8 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM2647 (1) (2A to >4A) Sync Switching Controller
		2.5V		LP2989-2.5 (<500 mA) LP3852-2.5 (<1.5A) LP3853-2.5 (<3A) LM3477A (2A to 4A) Switching Controller	LP3871-2.5 (<700 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller	LM2651-2.5 (1) (< 1.5A) LM2650-ADJ (1) (< 3A) LM2673-ADJ (2) (< 3A) LM2679-ADJ (2) (< 5A) 1/2 LM2647 (1) (2A to > 4A) Sync Switching Controller
		3.0V		LP3856-ADJ (<1A) LP2975 (1A to >4A)	LP3874-ADJ (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-ADJ (2) (<3A) LM2745 (>2A) Sync Controller	LM2653-ADJ (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-ADJ (2) (<3A) LM2679-ADJ (2) (<5A) 1/2 LM2647 (1) (2A to >4A) Sync Switching Controller
		3.3V		——	LP3871-3.3 (<800 mA) LM2852 (2A) Sync Regulator LM2650-ADJ (1) (<3A) LM2599-3.3 (2) (<3A) LM2745 (>2A) Sync Controller	LM2651-3.3 (1) (<1.5A) LM2650-ADJ (1) (<3A) LM2673-3.3 (2) (<3A) LM2679-3.3 (2) (<5A) 1/2 LM2647 (1) (2A to >4A) Sync Switching Controller

*Disclaimer: An accurate computation of power consumption is only possible when a detailed knowledge of the design is known.
(1) Synchronous switching regulator solution. Least heat dissipation. Maximum conversion efficiency.
(2) Buck switching regulator. Very good efficiency. Low heat dissipation.
(3) You can always use the other half of a dual controller to power V_{CCO} instead of the stand alone voltage regulator suggested.
**Suggested solutions are integrated regulators unless otherwise noted.

Voltage references, supervisors, and regulator portfolio

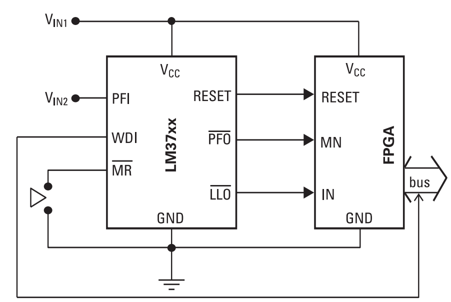
Recommended Voltage Supervisor Product Summary

Voltage Supervisors

National Semiconductor Solutions									
Part #	Monitor Voltage	Reset Flag Active	Package	Low-Line Output	Manual Reset	Power Fail Comp.	Watch Dog	Supply Reset	Pricing (1)
LM3700	3.3 (2)	Low	9 pin Micro-SM D	✓				✓	$0.40
LM3701	3.3 (2)	High	9 pin Micro-SM D	✓				✓	$0.40
LM3702	3.3 (2)	Low	9 pin Micro-SM D	✓	✓			✓	$0.45
LM3703	3.3 (2)	High	9 pin Micro-SM D	✓	✓			✓	$0.45
LM3704	3.3 (2)	Low	9 pin Micro-SM D	✓	✓	✓		✓	$0.85
LM3705	3.3 (2)	High	9 pin Micro-SM D	✓	✓	✓		✓	$0.85
LM3706	3.3 (2)	Low	9 pin Micro-SM D	✓		✓		✓	$0.95
LM3707	3.3 (2)	High	9 pin Micro-SM D	✓		✓		✓	$0.95
LM3708	3.3 (2)	Low	9 pin Micro-SM D	✓	✓		✓	✓	$1.00
LM3709	3.3 (2)	High	9 pin Micro-SM D	✓	✓		✓	✓	$1.00
LM3710	3.3 (2)	Low	9 pin Micro-SM D	✓	✓	✓	✓	✓	$1.10
LM3711	3.3 (2)	High	9 pin Micro-SM D	✓	✓	✓	✓	✓	$1.10
LM3712	3.3 (2)	Low	9 pin Micro-SM D		✓		✓	✓	$1.20
LM3713	3.3 (2)	High	9 pin Micro-SM D		✓	✓	✓	✓	$1.20
LM3722	2.5, 3.3, 5	Low	5 pin SOT-23		✓			✓	$0.80
LM3723	2.5, 3.3, 5	High	5 pin SOT-23		✓			✓	$0.80
LM3724	2.5, 3.3, 5	Low	5 pin SOT-23		✓			✓	$0.80

1. Budgetary 1k pricing in the US and the price published, may vary based upon packaging, grade, etc.
2. For custom reset threshold Voltages between 2.2V and 5.0V in 10 mV increments, contact National Semiconductor.

Example of a connection between a supervisor and an FPGA



LLO: Low-Line Logic Output (Early Warning)
PFI: Power-Fail Comparator Input
PFO: Power-Fail Logic Output (Monitors 2nd Voltage)
WDI: Watchdog Input (Asserts Reset Pin)
MR: Manual-Reset Input (Asserts Reset Pin)
Reset: Reset Logic Output

Recommended Voltage References and Termination Voltage Regulators

Voltage references and termination voltage regulators				
Standard	Voltage	National Semiconductor Solution(s) V_{IN} = 3.3V	4.5V < V_{IN} < 5.5V	V_{IN} = 12V
GTL	V_{REF} 0.8V	LM4140 -0.8	LM4140 - 0.8	LM4140 - 0.8 (5)
	V_{TT} 1.2V	LP3881 - 1.2 (<800 mA) LDO LM3460 - 1.2 (<7A) GTL Controller (6) LM2743 (1) (<20A) Sync Switching Controller	LM3460-1.2 (<4A) GTL Controller (6) LM2737 (1) (<20A) Sync Switching Controller	LM3460-1.2 (<1.5A) GTL Controller (6) LM2737 (1) (<20A) Sync Switching Controller
GTL+	V_{REF} 1V	LM4140 - 1.0	LM4140 - 1.0	LM4140 - 1.0 (5)
	V_{TT} 1.5V	LP3875 - ADJ (<1.5A) LDO LM3460 - 1.5 (<7A) GTL Controller (6) LM2743 (1) (<20A) Sync Switching Controller	LM3460 - 1.5 (<4A) GTL Controller (6) LM2737 (1) (<20A) Sync Switching Controller	LM3460 - 1.5 (<1.5A) GTL Controller (6) LM2737 (1) (<20A) Sync Switching Controller 1/2 LM5642 (<20A) Sync Switching Controller
HSTL Class I & II (Except 1.8V)	V_{REF} 0.75V	(included in LP2995 & LP2996)	LM4140 - 0.75	LM4140 - 0.75 (5)
	V_{TT} 0.75V	LP2994 / LP2995 / LP2996 (<1.5A) (2)	LM2737 (<20A) Sync Switching Controller	LM2737 (<20A) Sync Switching Controller 1/2 LM2647 (<20A) Sync Switching Controller (4)
HSTL Class III & IV (Except 1.8V)	V_{REF} 0.9V	(included in LP2995 & LP2996)	LM4140 - 0.9	LM4140 - 0.9 (5)
	V_{TT} 1.5V	LP2994 / LP2995 / LP2996 (<1.5A) (2)	LM2737 (<20A) Sync Switching Controller 1/2 LM5642 (<20A) Sync Switching Controller (3)	LM2737 (<20A) Sync Switching Controller 1/2 LM5642 (<20A) Sync Switching Controller (3)
SSTL2 Class I & II	V_{REF} 1.25V	(included in LP2995 & LP2996)	LM4121 - 1.2	LM4121 - 1.2
	V_{TT} 1.25V	LP2994 / LP2995 / LP2996 (<1.5A) (2)	LM2737 (<20A) Sync Switching Controller	LM2737 (<20A) Sync Switching Controller 1/2 LM2647 (<20A) Sync Switching Controller (4)
SSTL3 Class I & II, CTT	V_{REF} 1.5V	(included in LP2995 & LP2996)	LM4121 - ADJ	LM4121 - ADJ
	V_{TT} 1.5V	LP2994 / LP2995 / LP2996 (<1.5A) (2)	LM2737 (<20A) Sync Switching Controller 1/2 LM5642 (<20A) Sync Switching Controller (3)	LM2737 (<20A) Sync Switching Controller 1/2 LM5642 (<20A) Sync Switching Controller (3)

1. Least heat dissipation. Maximum conversion efficiency.
2. DDR termination linear regulator.
3. Good alternative (space saving, integration) when the other 1/2 LM5642 is already being used for V_{CCINT} or V_{CCO} supply.
4. Good alternative (space saving, integration) when the other 1/2 LM2647 is already being used for V_{CCINT} or V_{CCO} supply.
5. Max V_{IN} for LM4140s is 5.5V. Down convert V_{IN} first to 3.3V or 5.0V when using 12V supplies with LM4140s.
6. Linear solution. Careful thermal design needs to be followed. Heatsink is required for large output currents or large V_{IN}-V_{OUT} differentials.

Recommended Voltage Regulator Product Summary

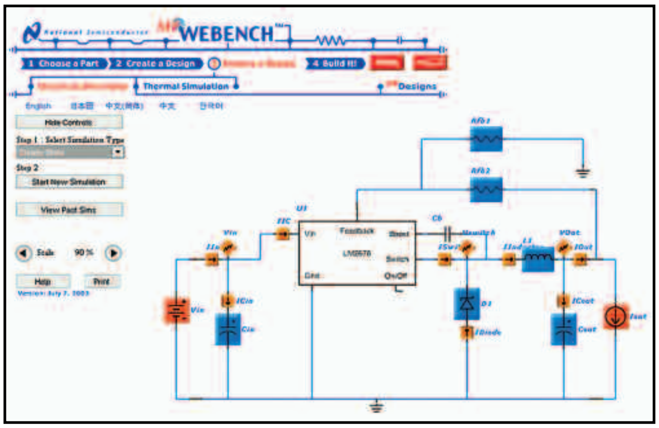
	National Semiconductor Solutions										
	Part #	Features	$I_{OUT\ (MAX)}$ (Amps)	Freq (kHz)	Sync Buck	V_{IN} (V) Min	V_{IN} (V) Max	Package			Pricing[1]
Integrated Switching Regulators	LM2593	Error Flag / Error Output Delay / Soft Start / 60V Input	2A	150		4.5V	60V	(7) TO-220	(7) TO-263		$2.69
Integrated Switching Regulators	LM2599	Error Flag / Error Output Delay / Soft Start	3A	150		4.5V	40V	(7) TO-220	(7) TO-263		$2.16
Integrated Switching Regulators	LM2650	Sync Rectification / 95% Efficiency / Shutdown	3A	90-300	✓	4.5V	18V	(24) SOIC			$3.50
Integrated Switching Regulators	LM2651	Low Power Sleep Mode / 97% Efficiency / Shutdown	1.5A	300	✓	4V	14V	(16) TSSOP			$1.68
Integrated Switching Regulators	LM2653	Adj. Powergood Delay and Soft Start	1.5A	300	✓	4V	14V	(16) TSSOP			$1.95
Integrated Switching Regulators	LM2655	Input-Output Protection / 97% Efficiency / Shutdown	2.5A	300	✓	4V	14V	(16) TSSOP			$1.68
Integrated Switching Regulators	LM2670	Frequency Sync / Shutdown	3A	260-400		8V	40V	(14) LLP	(7) TO-220	(7) TO-263	$1.98
Integrated Switching Regulators	LM2671	Frequency Sync / Shutdown / Soft Start	0.5A	260-400		8V	40V	(16) LLP	(8) SOIC	(8) MDIP	$1.38
Integrated Switching Regulators	LM2672	Frequency Sync / Shutdown / Soft Start	1A	260-400		8V	40V	(16) LLP	(8) SOIC	(8) MDIP	$1.76
Integrated Switching Regulators	LM2673	Programmable Current Limit / Soft Start	3A	260		8V	40V	(14) LLP	(7) TO-220	(7) TO-263	$1.98
Integrated Switching Regulators	LM2676	Shutdown	3A	260		8V	40V	(14) LLP	(7) TO-220	(7) TO-263	$1.88
Integrated Switching Regulators	LM2677	Frequency Sync / Shutdown	5A	260-400		8V	40V	(14) LLP	(7) TO-220	(7) TO-263	$3.58
Integrated Switching Regulators	LM2679	Programmable Current Limit / Soft Start	5A	260		8V	40V	(14) LLP	(7) TO-220	(7) TO-263	$3.14
Integrated Switching Regulators	NEW! LM2852	500/1500kHz Switching Frequency option	2A	500-1500		2.85V	5.5V	(14) TSSOP Exposed Pad			$2.35
Integrated Switching Regulators	NEW! LM3670	PWM & PFM Auto Switching, On/Off Pin	0.6A	1000		2.5V	5.5V	(5) SOT-23			$1.35
Integrated Switching Regulators	LM3671	PWM & PFM Auto Switching / Enable Pin	0.6A	2000		2.8V	5.5V	(5) SOT-23			$1.50
Switching Controllers	LM2636	5-Bit Programmable Output Volt / Powergood Flag	20A (2)	50-1000	✓	4.5V	5.5V	(20) SOIC	(20) TSSOP		$1.60
Switching Controllers	LM2642	Dual Synchronous Controller	20A (2) per channel	300	✓	4.5V	30V	(28) TSSOP			$1.80
Switching Controllers	LM2647	Dual Synchronous Controller	25A (2) per channel	200/500	✓	5.5V	28V	(28) LLP	(28) TSSOP		$2.00
Switching Controllers	LM2727	Sync / Sub Band-Gap Sync Controller / V_{CC} = 5V	20A (2)	50-2000	✓	2.2V	16V	(14) TSSOP			$1.25
Switching Controllers	NEW! LM2734	On/Off Pin, 94% Efficiency	1A	3000		3V	20V	(6) TSOT			$1.50
Switching Controllers	NEW! LM2736	On/Off Pin, Thin SOT-23 Package	0.75A	1600		3V	18V	(6) TSOT			$1.45
Switching Controllers	LM2737	Sync / 95% Efficiency / Powergood Flag / V_{CC} = 5V	20A (2)	50-2000	✓	2.2V	16V	(14) TSSOP			$1.25
Switching Controllers	LM2743	Sync / 95% Efficiency / Powergood Flag / V_{CC} = 3V to 6V	20A (2)	50-2000	✓	2.2V	16V	(14) TSSOP			$1.30
Switching Controllers	NEW! LM2745	Pre-bias Startup/Optional Clock Synchronization	20A(2)	50-1000	✓	3V	6V	(14) TSSOP			$1.60
Switching Controllers	NEW! LM3475	Hysteretic PFET, On/Off Pin	5A	1400		2.7V	10V	(5) SOT-23			$0.45
Switching Controllers	LM3477A	High-Side N-FET Controller / Current Mode Control	5A (2)	500		2.95V	35V	(8) mini SOIC			$0.90
Switching Controllers	LM5642	Dual Synchronous Controller w/ Oscillator Synchronization	25A (2) per channel	150-250	✓	4.5V	36V	(28) TSSOP			$1.90
LDOs	LP2960	Shutdown Control / Error Flag	0.5A	-		-20V	30V	(16) SOIC			$1.95
LDOs	LP2975	LDO Driver / Controller with Current Limit / min V_{CC} = 1.8V	5A (2)	-		1.24V	24V	(8) mini SOIC			$0.83
LDOs	LP2985	Stable with Output Ceramic Capacitors / Shutdown	0.15A	-		2.5V	16V	(5) Micro-SMD	(5) SOT-23		$0.26
LDOs	LP2989	Shutdown Control / Error Flag	0.5A	-		3.11V	16V	(8) LLP	(8) SOIC	(8) Mini SOIC	$1.05
LDOs	LP2992	Shutdown Control / Error Flag	0.25A	-		2.5V	16V	(5) SOT-23	(6) LLP		$0.45
LDOs	LP3852	Shutdown Control / Error Flag	1.5A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.88
LDOs	LP3853	Shutdown Control / Error Flag	3A	-		2.5V	7V	(5) TO-220	(5) TO-263		$2.83
LDOs	LP3855	Shutdown Control / Separate Sense Pin	1.5A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.75
LDOs	LP3856	Shutdown Control / Separate Sense Pin	3A	-		2.5V	7V	(5) TO-220	(5) TO-263		$2.83
LDOs	LP3871	Shutdown Control / Error Flag	0.8A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.15
LDOs	LP3872	Shutdown Control / Error Flag	1.5A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.37
LDOs	LP3873	Shutdown Control / Error Flag	3A	-		2.5V	7V	(5) TO-220	(5) TO-263		$1.74
LDOs	LP3874	Shutdown Control / Separate Sense Pin	0.8A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.15
LDOs	LP3875	Shutdown Control / Separate Sense Pin	1.5A	-		2.5V	7V	(5) SOT-223	(5) TO-263	(5) TO-220	$1.37
LDOs	LP3876	Shutdown Control / Separate Sense Pin	3A	-		2.5V	7V	(5) TO-220	(5) TO-263		$1.74
LDOs	LP3881	Shutdown Control / V_{CC} = 5V / Min V_{IN} = (V_{OUT} + 0.12V)	0.8A	-		1.36V	5.5V	(5) TO-220	(5) TO-263	(8) PSOP	$1.87
LDOs	LP3882	Shutdown Control / V_{CC} = 5V / Min V_{IN} = (V_{OUT} + 0.17V)	1.5A	-		1.47V	5.5V	(5) TO-220	(5) TO-263	(8) PSOP	$1.96
LDOs	LP3883	Shutdown Control / V_{CC} = 5V / Min V_{IN} = (V_{OUT} + 0.27V)	3A	-		1.67V	5.5V	(5) TO-220	(5) TO-263		$2.41
LDOs	LP3981	Micropower / Voltage Enable Pin / Separate Sense pin	0.3A	-		2.7V	6V	(6) LLP	(8) mini SOIC		$0.31
LDOs	LP3982	Micropower / Shutdown Control / Fault pin	0.3A	-		2.5V	6V	(8) LLP	(8) mini SOIC		$0.34
LDOs	LP3988	Micropower / Voltage Enable Pin / Powergood Flag	0.15A	-		2.7V	6V	(5) SOT-23	(5) micro SMI		$0.30
Vrefs	LM4121	Precision Series Voltage Reference 0.2% and 0.5%	± 5 mA	-		1.8V	12V	(5) SOT-23			$1.00
Vrefs	LM4140	Precision Series Voltage Reference 0.1% Sub-bandgap	8 mA	-		1.8V	5.5V	(8) SOIC			$1.50
Vrefs	LMV431	Adjustable (>1.24V) Shunt Reference / LDO Controller (2)	15 mA	-		1.24V	30V	(5) SOT-23	(3) TO-92		$0.34
Term.	LP2994	DDR Termination / Shutdown / Split Rails (3)	± 1.5	-		1.5V	5.5V	(8) SOIC			$0.50
Term.	LP2995	DDR Termination / V_{REF} Output	± 1.5	-		2.2V	5.5V	(16) LLP	(8) SOIC	(8) PSOP	$0.56
Term.	LP2996	DDR Termination / Shutdown / V_{REF} Output / Split Rails (3)	± 1.5	-		1.5V	5.5V	(16) LLP	(8) SOIC	(8) PSOP	$0.62
Term.	LM3460	Precision Controller for GTLp and GTL Bus Termination	7A (2)	-		-	20V	(5) SOT-23			$0.83

1. Budgetary 1k pricing in the US and the price published, may vary based upon packaging, grade, etc.
2. Output current using these controllers depends on a number of factors, including the MOSFET used, airflow, package, etc.
3. Independent power and analog rails.

Online design tools

WEBENCH™ design environment – simulate and optimize your designs using a variety of powerful tools

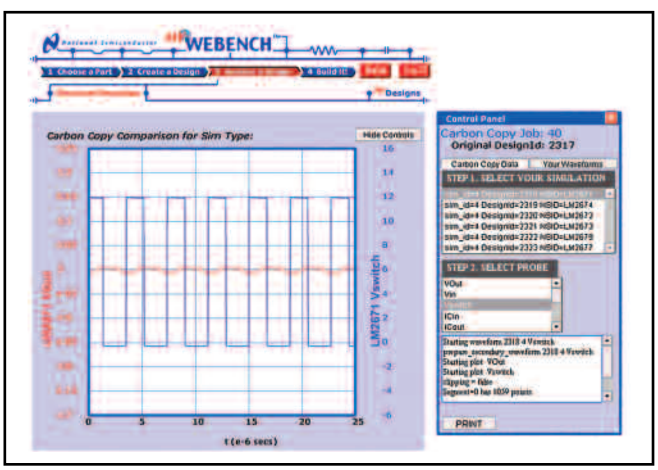
- Design, optimize and prototype your power supply products online
- Automated creation includes passive component selection
- Integrated environment provides superior optimization early in the design cycle
- Get your design to market faster than ever before



WEBENCH electrical simulator – performs electrical simulation for power supply designs

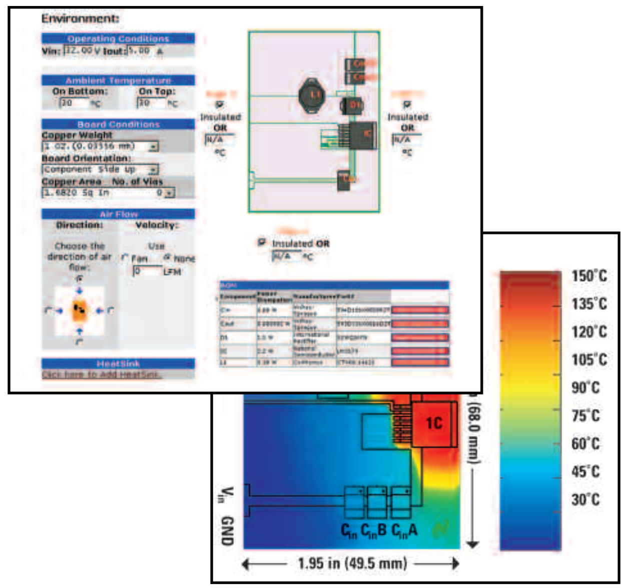
This advanced tool combines a sophisticated simulation engine with component models based on up-to-the-minute device information. It includes the following tests:

- Steady state
- Input line transient
- Output load transient
- Start-up
- Bode plot to check stability



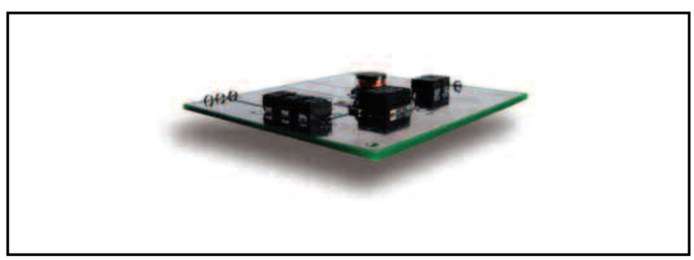
WebTHERM™ developed in cooperation with Flometrics simulates thermal behavior of power supply designs

- Provides a full-color plot that immediately identifies hot spots to help you identify failure points
- Delivers fast and accurate results using 3D conduction, radiation and convection algorithms
- Allows you to instantly change variables such as air velocity, copper area and heat sink to match your specific application



Build it – custom prototypes

- Get a custom prototype of your design quickly over the Internet
- Download custom documentation and CAD files
- Order a custom kit with 24 to 48 hour shipment
- Get a custom assembled board



For more information visit

- **www.webench.national.com**

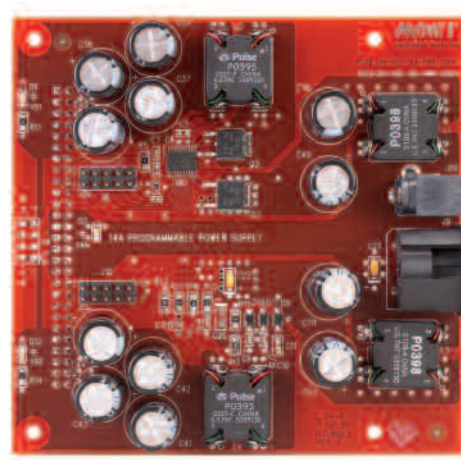
Programmable power supply kit

Many features of the National Semiconductor Dual LM2636 Programmable Power Supply Kit, by Avnet Design Services, are available to meet the specifications of Xilinx FPGA designs. The LM2636 Kit provides dual user-selectable output voltages between +1.3 and +3.5 VDC, thereby offering full support for Xilinx FPGA core voltages, V_{CCINT}, found in the Virtex, Virtex-E, Virtex-II, Virtex-II Pro, Spartan-II, and Spartan-IIE families including the additional support required for the I/O bank voltage, V_{CCO}, which specifies 1.5, 1.8, 2.5, 3.0, or 3.3 volt requirements. Both V_{CCINT} and V_{CCO} power requirements can be simultaneously supported with one kit, which includes a maximum of 14 amps per channel. V_{CCAUX}, V_{TT}, and V_{REF} voltages are also supported with the use of additional kits.

The Dual LM2636 Programmable Power Supply Kit, by Avnet Design Services, is designed with real FPGA applications in mind. It has all of the features demanded by this class of application: larger FPGA power requirements, multiple Xilinx family support, proper power-on ramp rates and the option to power sequence.

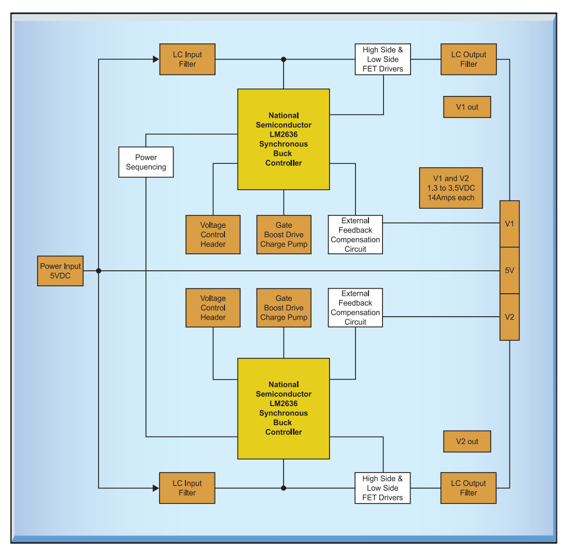
Description
The National Semiconductor LM2636 Programmable Power Supply Kit, created by Avnet Design Services, is a 28A DC-DC power supply. The design utilizes two National Semiconductor LM2636 synchronous buck controllers. Each controller is capable of supplying 14 amps with variable output voltages ranging from +1.3 VDC to +3.5 VDC. The design instantiates the LM2636 power good signals and is able to do a voltage follower power-up sequence. The board also has a +5 VDC feed through from the input source that can be used to supply a third voltage rail to the target board. A status signal indicating voltage is good on either output rail is also available at the target as well as an enable pin to shut both supplies off.

Ordering Information
Internet Link at: **www.em.avnet.com**
ADS-NSC-XP Dual National Power Supply
$250.00



Features

- +1.3 to +3.5 VDC programmable output
- Power good flag and output enable
- Capable of supplying 100 Watts of power
- Power sequencing between the two supplies
- Dependent or independent operation
- Over-voltage protection
- Current limit protection
- External ON/OFF control
- Meets Xilinx FPGA power requirements
- Miscellaneous
  - Multiple input power plugs
  - LED output indicators



Block Diagram

Application notes

National Semiconductor
www.power.national.com

AN-556	Introduction to power supplies
AN-558	Introduction to power MOSFETS and their applications
AN-643	EMI/RFI board design
AN-1028	Maximum power enhancement techniques for power packages
AN-1061	Power conversion in line-powered equipment
AN-1081	Multiple output converter using the LM2596 SIMPLE SWITCHER regulators
AN-1145	Using dynamic voltage positioning to reduce the number of output capacitors in microprocessor power supplies
AN-1146	Designing a multi-phase asynchronous buck regulator using the LM2639
AN-1148	Linear Regulators: Theory of operation and compensation
AN-1149	Layout guidelines for switching power supplies
AN-1197	Selecting inductors for buck converters
AN-1201	LLP-8 thermal performance and design guidelines
AN-1205	Electrical performance of packages
AN-1229	SIMPLE SWITCHER PCB layout guidelines
AN-1246	Stresses in wide-input DC-DC converters

Xilinx
www.xilinx.com

XAPP158	Powering Xilinx FPGAs
XAPP189	Powering Xilinx Spartan-II FPGAs
XAPP415	Packaging thermal management
XAPP450	Power-on requirements for the Spartan-II and Spartan-IIE families
XAPP453	The 3.3V Configuration of Spartan-3 FPGAs
XAPP623	Power Distribution System (PDS) design: using bypass/decoupling capacitors
XAPP659	Using 3.3V I/O guidelines in a Virtex-II Pro design

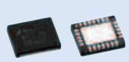
Avnet Design Services
www.em.avnet.com

ADS-003804	National Semiconductor LM2636 Dual High-Current Programmable Power Supply Kit-designing with the LM2636

Product Brief

National Semiconductor LM2636 Dual High-Current Programmable Power Supply Kit product brief

Packaging



LLP
(Leadless leadframe)
θ_{JA} 40 to 60° C/W

National's LLP® provides excellent power dissipation capability in a very small package footprint. Unlike conventional leaded plastic packages, the LLP contains pads on the bottom of the package for PCB mounting.

micro SMD
(small and large bump)
θ_{JA} 220 to 290° C/W

SO
(Small outline molded/ceramic)
θ_{JA} 100 to 190° C/W

SOT-223
(Power surface mount)
θ_{JA} 60 to 110° C/W

PSOP-8
θ_{JA} 43° C/W

SOT-23
θ_{JA} 120 to 290° C/W

TO-220
θ_{JA} 45 to 65° C/W

TO-263
(Power surface mount)
θ_{JA} 35 to 60° C/W

MSOP
(Mini 8-lead)
θ_{JA} 220° C/W

TSSOP
θ_{JA} 40 to 150° C/W

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Visit our Web site at:
www.national.com

For more information send email to:
support@nsc.com

National Semiconductor
The Sight & Sound of Information

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